CHAPTER 18: BOILER WATER CONTROL Part 2

LET'S SEE HOW TO MANAGE A WATER TREATMENT BASED ON PHOSPHATES AND SULFITES the oldest effective treatment of a fire-tube boiler with a working pressure of 10 Kg/cm2 (142 PSI)

METHOD FOR PERFORMING RAPID CONTROL ANALYSES OF BOILER PRODUCTS AND PURGES USING PHOSPHATE AND SULFITE BASED PRODUCTS.

1.- Sampling:

Take the boiler water sample using a 1/4 liter (or larger) plastic bottle that can be capped.

Take the sample from the continuous purge blowdown system, purging and rinsing the bottle with boiler water, ensuring you collect water from inside the boiler.

Cool the bottle in air or with water to room temperature (with the cap tightly sealed).

Analyze the boiler water sample as soon as possible.

2- Fill the conductivity meter cuvette 2 or 3 times to rinse it.

Immerse the conductivity meter electrodes, and after 3 minutes of immersion to allow for temperature compensation, measure the total dissolved salts (TDS).

We checked that the conductivity meter's battery was functioning correctly.

If the instrument reads more than 3,000 ppm (parts per million), we must increase the blowdown rate (open the continuous blowdown valve slightly more, continue bottom blowdown, and check levels every 4 hours).

If the reading is below 2,500 ppm, slightly close the continuous blowdown valve.

When the water softener is not functioning correctly, dissolved solids decrease, suspended salts (sludge) increase, and phosphates decrease.

Therefore, the softener must be monitored, and it is preferable to maintain low dissolved salt levels in the boiler (so that sludge is purged by bottom blowdown).

Adjust (calibrate) the conductivity meter at least every 3 months.

3- Sulfite Product Control (Oxygen and Chlorine Control):

In the same conductivity meter's container, moisten the sulfite measuring paper for about 5 seconds.

After 30 seconds, compare the reading to the color chart on the container tube. The value should be between 50 and 100 ppm as SO3- (sulfite radical).

If the value is lower than indicated, it could be due to:
- cold feedwater,
- insufficient sulfite being added,
- no sulfite being added during a shift (6 or 8 hours),
- excessive boiler purging (indicated by the conductivity meter),
- condensate being lost or discharged due to a broken line, resulting in excessive makeup water entering the system.

If Sulfite is missing, the amount can be increased if it is thought to be insufficient per shift, or an extra dose can be added if necessary to compensate if the shortage is due to a temporary problem (forgetting, breakage, excessive purging, etc.).

The disappearance of sulfite in the boiler water, or the use of higher quantities than expected, could be due to the introduction of chlorinated water. This should be investigated, since the only protection we have against chlorine (which is highly corrosive) and oxygen is an excess of sulfite.

Increased condensate and higher feedwater temperature reduce the need for sulfite because the boiler water has less oxygen.

In boilers with operating pressures above 40 kg/cm² (569 PSI), sodium sulfite **should not be used** because it tends to decompose, attacking the boiler metal instead of protecting it.

A boiler that is shut down (out of service) should always have an excess of sulfite of more than 100 ppm (and a pH greater than 10.5).

4- PHOSPHATES Control:

(scale, pH, and sludge control if combined with an organic sludge conditioner).

From the boiler water sample, fill the phosphate test tube (empty tube) to the mark (5 ml, second mark) after rinsing with the same water. Then add 4 drops of phosphate indicator from the dropper, cap it, and shake.

Wait 3-6 minutes. The yellow color of the water in the test tube should match that of the indicator sample (100 ppm orthophosphate radical).

If it is lighter in color: this could be due to a lack of PHOSPHATES, improper functioning of the water softener allowing hard water to pass through or introducing hardness through the condensate (in these cases, the boiler water will be cloudier and appear more purged on the conductivity meter), or due to forgetting to add products, or excessive purging (this is indicated by the dissolved salts reading on the conductivity meter).

Pollution can also come from the steam lines when the boiler is stopped (a vacuum is produced).

5- pH Control:

Using pH paper, immerse it in the same cuvette as the conductivity meter for about 5 seconds, then compare the result to the color chart.

The alkalinity due to sodium hydroxide comes from the water softener, which converts all the calcium and magnesium bicarbonates into sodium bicarbonates.

These decompose at the boiler water temperature, leaving sodium hydroxide as the pH of which must be limited to 11.5, given the problem of hydroxide corrosion and, fundamentally, the formation of foam.

This foam contaminates the steam and creates the risk of massive boiler water carryover, leaving heat exchange surfaces under-cooled and at risk of overheating.

This is primarily due to boiler water being present in the steam, which causes water hammer (masses of water impacting against changes in steam direction, especially against heat exchange equipment). Furthermore, the steam becomes a contaminant in boiler water used in various processes (food processing, textiles, etc.).

If the water is acidic, soda (in the form of sodium hydroxide, i.e., caustic soda, in flakes, pearls, or liquid form at 50% concentration, or as sodium ash, which is less hazardous to handle) must be added to achieve a pH above 10.5

This will ensure "free soda" in the boiler water at low and medium pressures. However, as boilers operate at higher pressures, the "free soda" (hydroxide alkalinity) in the boiler water must be reduced.

From 40 kg/cm² (569 PSI) upwards, there should be no "free soda" or hydroxide alkalinity (as at high pressures, soda can attack the high-vaporization heat transfer surfaces).

This type of treatment is called "congruent" and follows a pH curve that decreases from 11.5 as the pressure increases.

This is achieved by using more acidic phosphates (disodium phosphate, Monosodium and as a partial replacement for trisodium phosphate (which contains more sodium); polyphosphates with varying amounts of sodium in their composition can also be used.

The pH should be between 10.5 and 11.5.

If the pH is above 11.5, almost 12, we must perform more purging even if the TDS is below 2,500 ppm. This is generally due to water conditions during dry periods if the water softener is functioning properly.

Also, if purging is insufficient, the pH will be above 11.5.

A pH above 12 makes boiler operation dangerous, potentially causing it to collapse due to poor internal circulation.

If the pH is low, it could be due to: contamination, condensate return, a malfunctioning water softener, or the introduction of hard water (in this case, phosphate levels also decrease, and the water becomes cloudy).

The boiler, when shut down (out of service), should have a pH above 10.5, ideally 11 to 11.5.
If necessary, add a small amount of caustic soda or soda ash along with "product M" (a product sold by C.W.T. Boiler treatment dealers).

Example: Add 100 g of soda per m^3 of boiler water.

The boiler in operation should be analyzed every shift (6 or 8 hours) for softener hardness, and the limit values should be checked once a day or twice a week, or whenever problems are suspected (such as level disturbances, turbidity, etc.).

The boiler when stopped should be checked every 15 days.

If products are added to the stopped boiler, it should be briefly turned on until steam is released from the atmospheric valve, and then flooded.

Rinse all test equipment thoroughly, especially the conductivity meter tank.

When increasing the amount of products, do so in small percentages (20% at a time) and wait a couple of days before retesting.

If you need to correct a product shortage, add an extra measure once (one shift).

For calculating the makeup water, it is assumed that for every 1 liter of fuel oil, approximately 13 liters of water evaporate (for firewood with 25% HBh, this can be said to be equivalent to approximately 4 liters of water per 1 kg of firewood).

Assuming condensate is 30% and purge is 30% of the makeup water (well water with high salinity and alkalinity), we can assume that for every 100 liters of fuel oil, we are adding 100 x 13 x (1-30/100) x (1+30/100) = 1.183 liters.

Rounding this to a makeup water requirement of 1.2 m^3/100 liters of fuel oil.

Using a similar calculation, based on the daily fuel oil consumption, we can calculate the required cubic meters. of makeup water, which allows us to calculate the theoretical amount of Phosphate (depending on the type of phosphate), but generally 30-40 g/m^3, and of Sulfite, generally 60-80 g/m^3, if the feed water temperature is suitable.

These values are then adjusted by the phosphate and sulfite analyses (indicated above).

Purge drain (blowdown) water levels every 4 hours, perform a bottom drain at least once per shift, and drain collectors (gas generator) whenever there is an opportunity for low vaporization (at least once a day, once a week).

Continuous drain is calculated according to the TDS (Total Dissolved Solids) of the makeup water.

If it is well water, the continuous puge drain should be no less than 20% of the makeup water.

In reverse osmosis water with very low salinity, the purge drain should be maintained at 5% to prevent excessive condensate concentration cycles.

Condensate return contains many impurities, from iron oxides to small amounts of other products that penetrate through leaks in the heating surfaces.

Continuous purging allows for TSD adjustment by opening or closing according to the reading, while maintaining the bottom and level purges so that TSD adjustment doesn't have to be done with these purges.

These purges are primarily used to remove sludge (bottom purge) and, in the case of the level controls, to clean the control bodies of sludge and test that they shut off the burner (or the air and induced draft in wood combustion) in case of a low water level (very important for boiler safety).

CHEMICAL LIMITS FOR BOILER WATER:

The limits to be set for the chemical treatment of the elements present in boiler water generally depend on the pressure, but also on the type of boiler and the intended use of the steam (high-quality steam for food processing or textile dyeing).

The main limit is determined by the element that has the greatest impact on the makeup water and the treatment it undergoes.

To determine the blowdown percentage, not only must the total dissolved solids (TDS) be considered, but other factors must also be taken into account, such as: the maximum permissible silica content for the pressure, steam usage, the possibility of silica scaling, highly insulating scale that is very difficult to remove, etc.

In low-pressure boilers, the silica content should generally not exceed 300 ppm as SiO_2 (meaning that if the makeup water has a high silica content, the concentration cycles must be reduced to the maximum established).

We must also consider the total alkalinity (the alkaline salts present in the makeup water, such as hydroxides, carbonates, and bicarbonates), which generally has a total alkalinity limit of 900 ppm as $CaCO_3$ at low pressure.

This means that some well water sources with high alkalinity cannot be cycled for more than 2 to 3 cycles. (This is a very high blowdown.)

The other element to consider is the total suspended solids, which at low pressure should generally not exceed 300 ppm (generally, the water will arrive without suspended solids, but if hard salts enter the boiler, these will precipitate and form suspended solids that will cause problems with internal circulation, foaming, etc.).

These limits, combined, have cumulative effects, and the concentration cycles should be reduced.

All these limits will be lower as the boiler operates at higher pressures or the required steam quality becomes more demanding.

pH is a very important limit. At low pressure, it's advisable not to operate above pH 11.5 (this causes the loss of magnetic oxide, the layer that protects the boiler metal from corrosion), nor below pH 10.5 (a value that also causes the loss of the protective oxide layer due to acidity).

In medium and high-pressure boilers, problems arise that necessitate operating at pH levels lower than 11.5, since
on high heat transfer surfaces, localized areas with high concentrations of free soda (which attacks the metal) develop.

These operating pH values depend on the pressure and type of treatment. Generally, this type of treatment with strict pH control (at values below pH 11.5) is called "congruent chemical treatment" (usually done with phosphates combined with varying amounts of sodium, so that no free sodium or hydroxide alkalinity remains).

We can say that pH is the result of the ratio of alkalinities, and that free soda is equivalent to the phenolphthalein alkalinity multiplied by 2 minus the total alkalinity (methyl orange).

Based on our experience, we can say and advise that in low-pressure boilers (fire-tube boilers, and even more strictly in water-tube boilers), it is not advisable to operate with free soda above 450 ppm (as $CaCO_3$), as this can cause serious internal water circulation problems, endangering the integrity of the boiler (even leading to combustion chamber failure).

In high-pressure boilers, to avoid introducing salts that could accumulate in the boiler water, some methods use volatile elements (meaning they act in the boiler as they pass through, without leaving residues).

Of course, these treatments cannot use water containing elements that could precipitate, accumulate, etc. (the water is completely demineralized, with very high resistivity, silica control, and no room for error in the treatment of the replacement water).

The ASME (American Society of Mechanical Engineers, through its Steam and Water in Thermal Power Systems Committee) has recommended maximum acceptable limits for both feedwater and boiler water (set for water-tube boilers). Let's look at some of these boiler water limits, which are based on pressure.

ASME RECOMMENDED CHEMICAL LIMIT TABLE FOR BOILERS

Pressure (Kg/cm2)	0-21	21-31	31-42	42-53	53-63	63-70	70-105	105-140
(PSI)	0-300	300-440	440-600	600-750	750-900	900-1000	1000-1500	1500-2000
Silica (mg/l SiO2)	≤150	≤90	≤40	≤30	≤20	≤8	≤2	<1
Total Alc. (mg/l)	<350	<300	<250	<200	<150	<100	-	-
Hydroxide Alc. (mg/l)	Not specified.....							
Conductivity (µS/cm)	<3500	<3000	<2500	<2000	<1500	<1000	≤150	≤100

Alkalinity is measured in CaCO3 (calcium carbonate), and conductivity is measured without neutralization (i.e., the boiler water as it is when the sample is taken; if we want to express it as ppm - parts per million - divide the µS/cm by 1.5).

This table is very theoretical; a number of factors must be considered to set the limits, not just pressure (pressure, boiler type, desired steam quality, type of plant to be fed with steam, etc.).

This task should be recommended by the steam treatment specialist based on their knowledge and experience.

In fire-tube boilers, at low pressure, the limits are more generous, depending on the desired steam quality, makeup water quality, type of process to be fed with steam, type of combustion, etc.

CURVE FOR CONSISTENT (COORDINATED) PHOSPHATE-BASED TREATMENT

This graph separates, with a curve, the zone without free soda ash (NaOH) or alkali hydroxide (yellow zone), where medium-high and high-pressure boilers operate, i.e., above approximately 40 kg/cm² (569 PSI),

and the zone with free soda ash (NaOH), where low and medium-low pressures are used, up to approximately 40 kg/cm² (569 PSI).

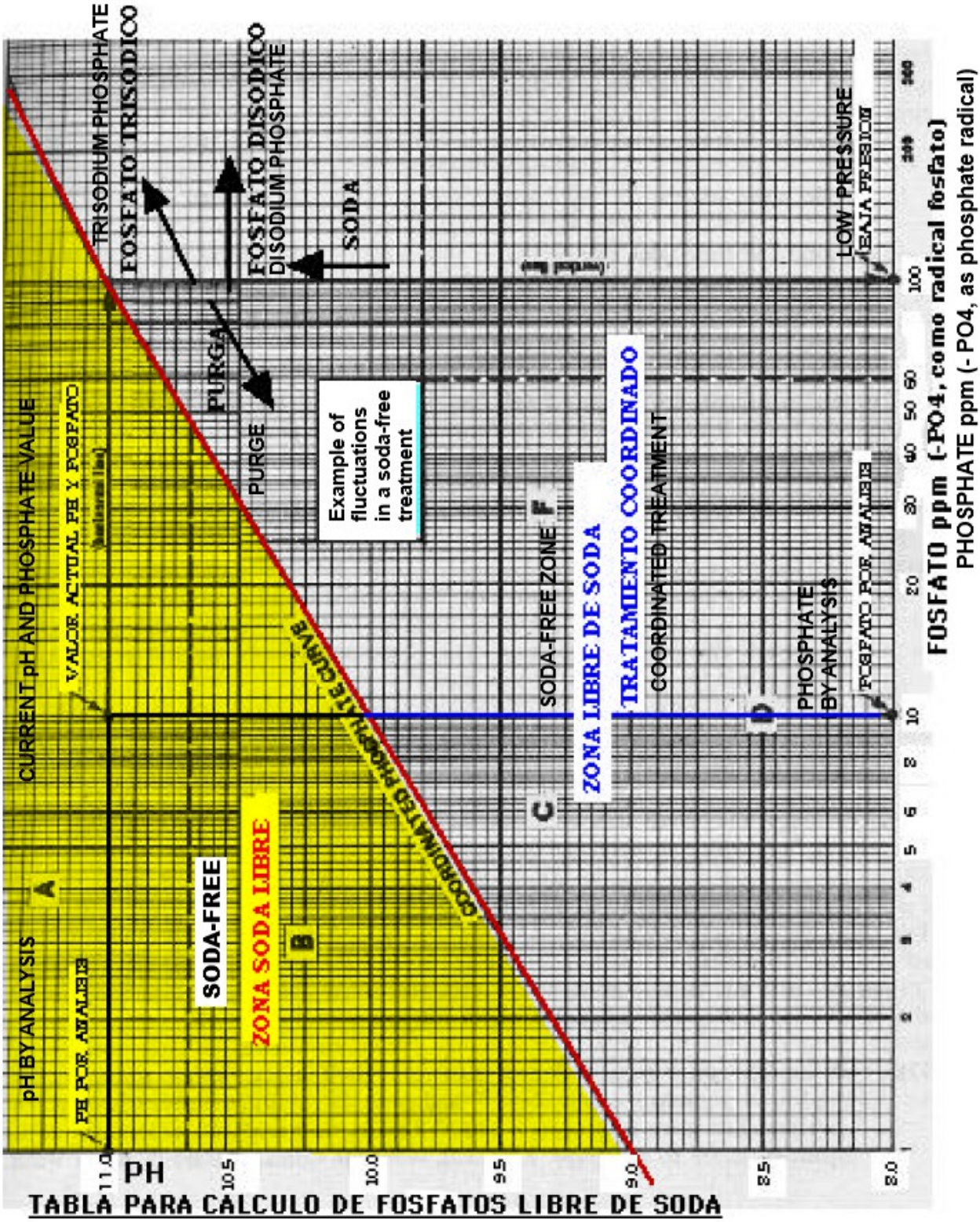


TABLE FOR CALCULATING SODA-FREE PHOSPHATES

The phosphates we can use are Trisodium Phosphate (Na3PO4), which raises the pH along the curve, and Disodium Phosphate (Na2PO4), which follows the horizontal line, maintaining a constant pH.

Sodium Hydroxide raises the pH value vertically.

Blowdown is what lowers the pH (generally, continuous or emergency purge blowdown is the bottom blowdown with the burner off at low pressure.

At medium, high, and high pressures, bottom blowdowns should not be used at full boiler pressure, as water hammer can cause significant damage).

To determine if we have free soda (sodium hydroxide) in the boiler water, we can use not only this chart, but also measure the Phenolphthalein Alkalinity (whose transition pH is around 8.3-8.4).

We also measure the Total Alkalinity (using Methyl Orange, whose transition pH is around 4.3-4.4).

Multiplying the Phenolphthalein Alkalinity by 2 and subtracting the Total Alkalinity gives us the Hydroxide Alkalinity (which is the same as free soda).

The result is expressed as free sodium hydroxide in the same units used to measure the previous alkalinities.

This analysis is very important, since at low pressure it allows us to see if we have problems with the water softener.

A major contributor of sodium bicarbonate to temporary hardness, which,

when entering the boiler, releases the soda and carbon dioxide, which is released with the steam as it decomposes with the heat.

COMMON PHOSPHATES FOR PHOSPHATE TREATMENTS:

Trisodium Phosphate with 12 water molecules $Na_3PO_4 \cdot 12H_2O$ (the most common, with 18.3% phosphate as P_2O_5; it contains the least amount of phosphate)

Trisodium Phosphate with 1 water molecule $Na_3PO_4 \cdot 12H_2O$ (supposedly "anhydrous," meaning dry; it has 39.5% phosphate as P_2O_5 because it contains less water per kg)

Sodium Diphosphate Na_2HPO_4 (anhydrous, since it contains no water molecules, and has a phosphate yield of 48.0% as P_2O_5)

Sodium Diphosphate with 12 water molecules $Na_2HPO_4 \cdot 12H_2O$ (has a yield of 19.0% as P_2O_5)

Sodium monophosphate, there are two, one anhydrous, without water molecules and one with 1 water molecule, they are used relatively little (except as Hexametaphosphate).

Polyphosphates are used to great advantage in phosphate treatment because they do not precipitate with the hard water in the feed tank. Instead, they complex with the water, preventing damage to the feed pumps and valves. Only with the heat of the boiler water do they decompose into basic phosphates, forming phosphate salts.

These are sodium hexametaphosphate $[Na(PO_3)]_6$, sodium tripolyphosphate ($Na_3P_3O_{10}$), and tetrasodium pyrophosphate ($Na_4P_2O_7$). The one containing the least sodium is the first, sodium hexametaphosphate ($[Na PO_3]_6$).

The great advantage of these phosphates is that they are used in most household cleaning products and some in food manufacturing (dairy and others), which indicates their low potential for contamination that could cause harm (except in effluents with large amounts of phosphates that cause algae growth).

It's important to remember that when using phosphate-based treatments, if the pH is very low, the phosphates themselves can cause scaling due to the hardness.

A major advantage of phosphate treatments is that the phosphate not only reacts with the water hardness to form sludge precipitates, but also, with the help of a sludge conditioner to prevent them from sticking to surfaces, they are removed by bottom blowdowns.

Natural organic conditioners (such as cornstarch) are preferable; they are less polluting and their role in corrosion, though not yet fully understood, contributes to keeping corrosion at very low levels.

Boilers with tubes that last for more than 30 years without surface alteration.

The use of sodium sulfite (Na_2SO_3) for oxygen and chlorine scavenging (when the feedwater comes from water treated with sodium hypochlorite) is problematic.

Sodium hypochlorite is highly corrosive in the hot boiler,. While oxygen is corrosive in the cold boiler but corrosive in the condensate system, amplifying the carbon dioxide (CO_2) produced by the decomposition of sodium, calcium, or magnesium bicarbonates at high temperatures inside the boiler.

Its use is limited to pressures of up to 40 kg/cm2 (569 PSI), as it decomposes at higher pressures and causes corrosion in the boiler and the steam and condensate systems.

In boilers operating above 40 kg/cm2 (569 PSI), another oxygen scavenger, not sulfite, should be used.

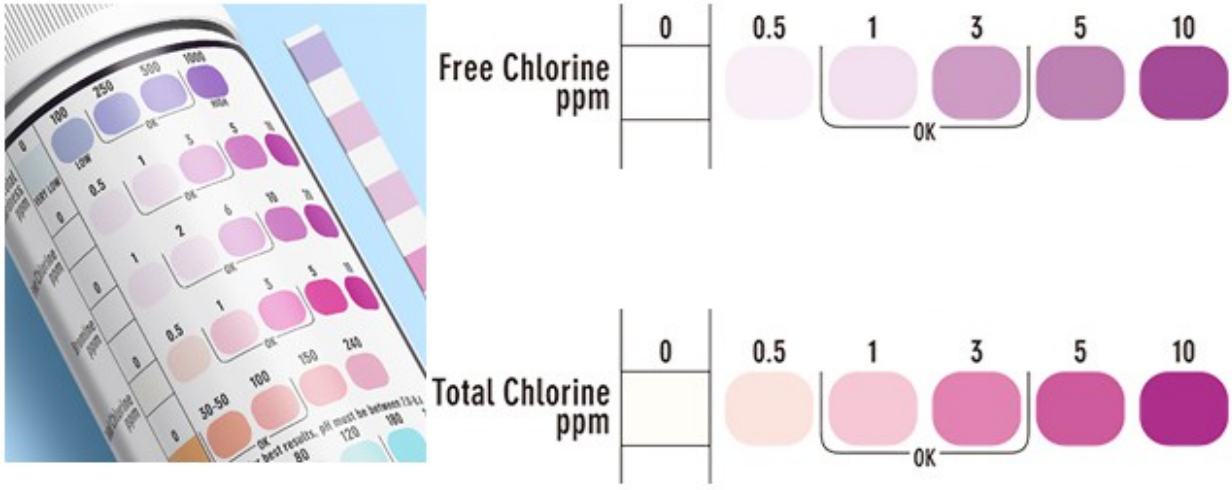
The great advantage of sodium sulfite is that it is not a "pollutant", whereas other oxygen scavengers are.

As a precaution, it is advisable to remove any free chlorine that may be present in the feed water (not to be confused with the chloride ion), as it is highly corrosive unless protected by a sufficient amount of sulfite.

Therefore, it is advisable to have an activated carbon filter to remove the chlorine (from the disinfectant hypochlorite or gaseous chlorine injected into the water for disinfection). Activated carbon absorbs the gases that pass through its highly porous bed. These filters are similar to water softeners in their physical operation.

Although they are backwashed periodically to remove any sludge that the water may contain, the effect of the chlorine trapped in the activated carbon will cause it to deplete over time, requiring periodic replacement.

For this reason, it is essential to verify that the water passing through the carbon filter is chlorine-free (through free or total chlorine analysis).



Regarding oxygen, if we don't have a deaerator (in the feedwater tank), the consumption of sodium sulfite can be very high, causing an increase in Total Dissolved Salts (TSD) in the boiler water, which necessitates more blowdown.

Therefore, if we don't have a deaerator, we must heat the feedwater as close as possible to 100°C (212°F) so that the gases are expelled from the water.

When treating "locomotive" boilers (from railways, for example), it's advisable to consider using tannins (formerly quebracho tree extract) along with the treatment, since these boilers are riveted and can suffer from "fragility" problems in the water, which could cause an accident.

Tannins not only help prevent this, but they also partially protect against oxygen corrosion and are excellent dispersants of deposits that tend to form on metal surfaces.

Today, tannin is synthetic. We have been using it for many years in the boiler of the "Heart of Fire" locomotive (famous by an uruguayan film “CORAZON DE FUEGO” or “EL ULTIMO TREN” year 2002) with great success.

Locomotora a leña "CORAZON DE FUEGO"

The frequency of boiler water analysis should depend on the plant's operation (potential for contamination, such as in a sugar factory where condensate may contain sugar, using alpha-naphthol and sulfuric acid to detect its presence hourly or upon suspicion due to foaming, and other types of polluting factories like cold storage facilities, meat processing plants, etc.).

However, the minimum frequency for boiler analysis is once a week, provided it is a low-risk, low-pressure installation.

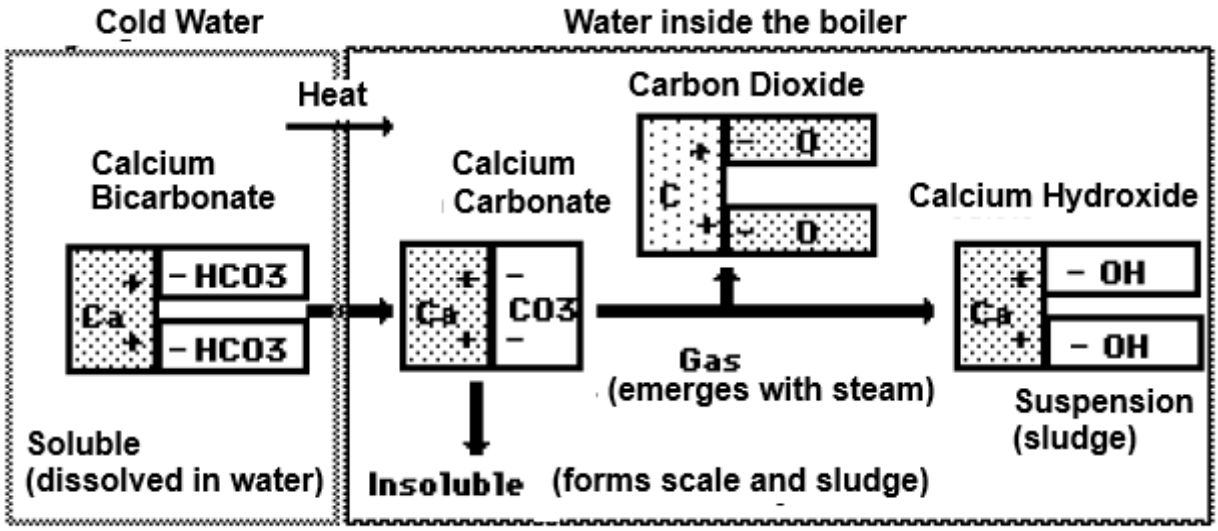
What I support is that the boiler operators should do the basic analyses and the central laboratory should do the control analyses that require more laboratory work, but the boiler operator is in constant contact with the boiler and can take immediate measures based on the analyses he has done or do the analyses when he suspects that something is wrong with the water (such as: level fluctuations, foam, etc.).

Common chemical reactions in boiler water:

These reactions occur when different salts (or the salts themselves due to other factors) come into contact, reacting through the exchange of their atoms or ions to establish a new chemical equilibrium (activated by elements that aid this reaction, such as temperature, pH, catalysts, etc.).

Bicarbonates (sodium, calcium, and magnesium), highly soluble salts very common in boiler makeup water, transform into other salts or gases upon entering the boiler due to the high temperature.

When calcium bicarbonate comes into contact with the hot water in the boiler, the following final reactions occur:



Calcium carbonate precipitates (this is the marble we see in nature), forming scale and sludge.

Carbon dioxide is a gas (the same gas produced by carbon combustion and used to extinguish fires). It dissolves again in cold water, lowering the pH of the condensate and attacking the iron in the pipes in the presence of oxygen.

Calcium hydroxide forms sludge because it is not very soluble (this is the lime we use for whitewashing).

Something similar happens with other bicarbonates, but in the case of sodium bicarbonate, it forms highly soluble carbonates and hydroxides, which are normally dissolved in the boiler, creating the "alkalinity" needed to maintain a suitable pH in the water (provided it is not excessive, resulting in a

very high pH, or in very high-pressure boilers where free sodium is not possible).

WATER HARDNESS

TOTAL HARDNESS = CALCIUM AND MAGNESIUM SALTS
TEMPORARY HARDNESS = CALCIUM AND MAGNESIUM BICARBONATES
Precipitate with temperature (heat)

PERMANENT HARDNESS = CALCIUM AND MAGNESIUM SULFATES AND CHLORIDES

Precipitate with concentration

Other common reactions in boiler water:

Magnesium bicarbonate = Magnesium carbonate + water + carbon dioxide
$Mg(HCO3)2 = MgCO3 + H2O + CO2$

Magnesium carbonate + water = Magnesium hydroxide + carbon dioxide
$MgCO3 + H2O = Mg(OH)2 + CO2$

These salts, containing calcium and magnesium, decompose to form the "temporary" hardness of the water. They are called temporary because they decompose in the presence of heat.

However, there are also salts that form the "permanent hardness" of the water, which, added to the "temporary hardness," forms the "total hardness" of the water.

These salts are:

Calcium sulfate ..... $CaSO4$, Magnesium sulfate ..... $MgSO4$
Calcium chloride ..... $CaCl2$, Magnesium chlorides..... $MgCl2$

They react with other salts:

Magnesium chloride + water = Magnesium hydroxide + hydrochloric acid
$MgCl2 + H2O = Mg(OH)2 + 2\ Hcl$

This reaction is very corrosive due to the chloride ion, but in a properly treated boiler the following occurs:

If there is a water softener, it exchanges the Mg outside the boiler; if this does not happen, it will react with the alkalinity of the boiler due to the sodium:

Magnesium chloride + Sodium hydroxide = Magnesium hydroxide + Sodium chloride

$MgCl_2 + 2\ NaOH = Mg(OH)_2 + 2\ NaCl$

Sodium chloride is a very stable salt, but it is corrosive at high concentrations (it is table salt). We use it as a tracer to monitor purge blowdown by measuring the chloride ion (to establish concentration cycles).

Calcium and magnesium sulfates are more prone to scaling, as their saturation decreases with increasing temperature.

Therefore, the hardness must be removed before it enters the boiler, or non-scaling sludge must be formed with appropriate internal treatment.

For example, with phosphates:

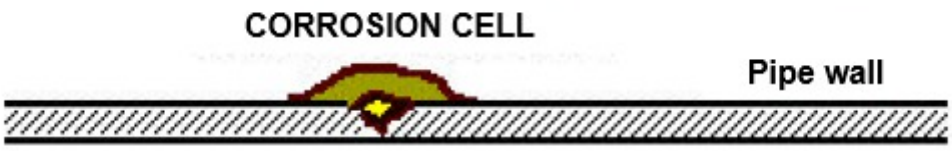
Calcium sulfate + Trisodium phosphate = Calcium phosphate + Sodium sulfate

$3\ CaSO_4 + 2\ Na_3PO_4 = Ca_3(PO_4)_2 + 3\ Na_2SO_4$

With sufficient free alkalinity, a non-scaling calcium phosphate is formed, which precipitates as sludge, and a sodium sulfate salt that does not produce scale or sludge.

Calcium chloride + Trisodium phosphate = Tricalcium phosphate + Sodium chloride
$3\ CaCl_2 + 2\ Na_3PO_4 = Ca_3(PO_4)_2 + 6\ NaCl$

Similar reaction to the previous one.



MOST IMPORTANT OXYGEN CORROSION: "PITTING"

There are many more reactions related to the salts present in the water and those we add to counteract their effect.

Now we will look at some of the reactions used to remove oxygen from the water.

First, the higher the feed temperature, the lower the amount of oxygen the water can hold, and therefore the fewer chemicals we need to use.

The most common chemicals are:

Sodium sulfite + oxygen = Sodium sulfate
$2\ Na_2SO_3 + O_2 = 2\ Na_2SO_4$

In the case of using hydrazine:

Hydrazine + Oxygen = Water + Nitrogen
$N_2H_4 + O_2 = 2\ H_2O + N_2$

This reaction does not form salts that contribute to the TDS (Total Dissolved Salts) of the boiler water, as it forms nitrogen (an inert gas).

Hydrazine has the disadvantage of being considered a hazardous substance (carcinogenic).

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